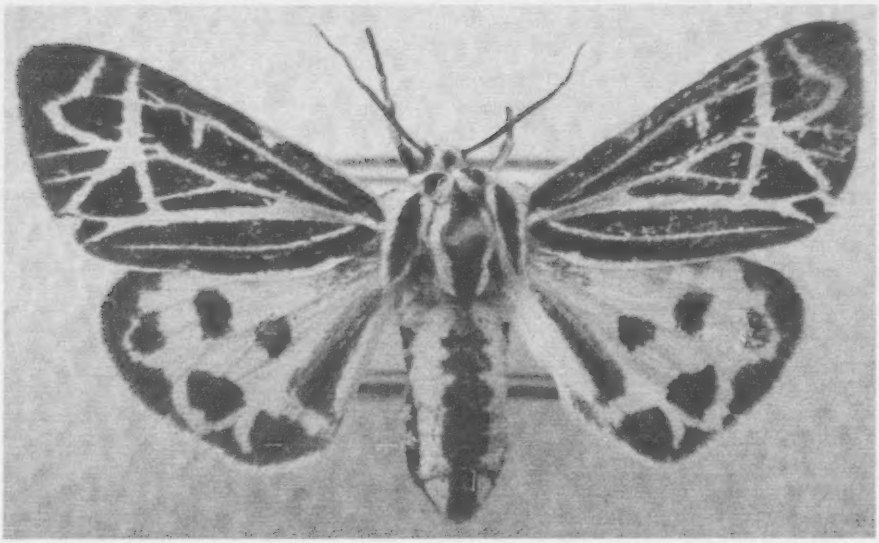
COSEWIC
Assessment and Status Report

on the

Island Tiger Moth
Grammia complicata

in Canada



THREATENED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Island Tiger Moth

Scientific name
Grammia complicata

Status
Threatened

Reason for designation
This near endemic moth has a small distribution and is restricted to only 5 locations in the Georgia Basin in British Columbia. Much of its habitat has been destroyed and the quality of what remains is declining due to ongoing residential and commercial development, recreational activities, invasive or non-native species, and vegetation succession that has changed due to disruption of former fire regimes.

Occurrence
British Columbia

Status history
Designated Threatened in May 2013.

COSEWIC
Executive Summary

Island Tiger Moth
Grammia complicata

Wildlife Species Description and Significance

Island Tiger Moth (*Grammia complicata* Walker) is a medium sized moth (wingspan 32 mm to 40 mm) in the family Erebidae, subfamily Arctiinae. The upper wing surfaces vary from dark brown-black interlaced with whitish to pale orange patterns along the wing veins; to the converse, with an orange-peach background with dark brown-black vein-like patterns. The hind wings are typically lighter than the forewings, pale orange, with brown dots towards the outer wing margins which are also brown. The head, thorax and abdomen are dark brown-black with peach-orange markings. In general,Tiger moth (*Grammia* spp.) larvae are up to 6 cm long, have black - orange lateral stripes and are densely covered in dark hairs. This species was recently (2009) separated from the Ornate Tiger Moth based on morphological and genetic evidence.

Distribution

Island Tiger Moth is endemic to the Georgia Basin. With the exception of one record from Orcas Island, Washington State, the moth is a Canadian endemic. On Vancouver Island, Island Tiger Moth ranges from the Greater Victoria area north to Comox and there are records from Thetis, Sandy and Savary Islands. Based on historical and current records, the species' Canadian range is 3600 km^2.

Island Tiger Moth is considered extant at five sites in B.C.: Goose Spit, Sandy Island, Nanoose Hill, Savary Island and Thetis Island. The habitat at some sites span multiple landowners. The record on Thetis Island is considered old (1975) although there is much potential habitat on the island and the moth may be present. Based on the threat of land development (due to land ownership), there are 5 – 8 locations.

Habitat

Island Tiger Moth has been recorded from a variety of habitat types including open and grassy Garry Oak forest; open moist to dry meadows; grassy shoreline sandy areas and in more stabilized, sparsely vegetated areas in sand dunes. The Moths of the genus *Grammia* typically do not inhabit closed forest habitats. The larval host plants for Island Tiger Moth are unknown, although tiger moths are known to be generalist herbivores. There is an early record of larvae being collected on introduced English Plantain.

Biology

According to museum and collection records Island Tiger Moth adults are active from May through late July. Larvae have been collected in both early March and late July. Females have heavy bodies and comparatively small wings: they are incapable of more than short distance dispersal.

Population Sizes and Trends

Information on Island Tiger Moth population sizes and trends in B.C. is minimal. Most records are historical or a single individual at one site on one date.

Threats and Limiting Factors

Threats to Island Tiger Moth and its associated habitat include residential and commercial development, recreational activities, and vegetative succession from both invasive and native species.

Protection, Status, and Ranks

Island Tiger Moth is not protected by any existing legislation. Within provincial parks parks and protected areas, lands managers are aware of the moth's records within parks, although detailed provisions in park management planning have yet to be addressed. The B.C. Conservation Data Centre has not assigned the moth a conservation status rank, although preliminary status ranking places the moth at S1 Red-listed (Critically Imperilled). The global status rank is G1G2 (critically imperiled). The Canadian and B.C .general status rank is "May Be At Risk".

TECHNICAL SUMMARY

Grammia complicata
Island Tiger Moth
Range of occurrence in Canada:British Columbia

Apantèse compliquée

Demographic Information

Generation time	1 yr
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Inferred decline due to habitat loss
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Not reversible; somewhat understood; not ceased
Are there extreme fluctuations in number of mature individuals?	Unknown; not likely.

Extent and Occupancy Information

Estimated extent of occurrence 1881 km² based on recent sites (since 1975) 3600 km² based on historical and recent sites;	1881 km²
Index of area of occupancy (IAO) 76 km² based on historical and recent sites; 20 km² based on five recent sites (Figure 3)	20 km²
Is the total population severely fragmented?	Likely, recent sites are >7 km from the next closest site and are separated by ocean. Loss of any one site would have a large impact on the total Canadian population and result in a large range gap
Number of locations*	5 - 8 based on the potential of development, based on land ownership (see Figure 2 and Table 2)
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Yes, inferred, based on habitat loss and fragmentation of habitats

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes, inferred, based on habitat loss and fragmentation of habitats
Is there an [observed, inferred, or projected] continuing decline in number of populations?	A reduction can be projected based on habitat loss and fragmentation of habitats.
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Yes, inferred, based on habitat loss and fragmentation of habitats
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes, inferred, based on habitat loss and fragmentation of habitats
Are there extreme fluctuations in number of populations?	Unlikely
Are there extreme fluctuations in number of locations*?	Unlikely
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	Unlikely

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not Applicable

Threats (actual or imminent, to populations or habitats)

Development (urban, recreational, infrastructural), succession, invasive species, demographic collapse, BtK spraying, climate change-related impacts

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Known from only 1 population in Washington state, most likely at greater conservation risk there
Is immigration known or possible?	Highly improbable given limited vagility of females
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Perhaps
Is rescue from outside populations likely?	No

Status History

COSEWIC: Designated Threatened in May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	B1ab(iii)+2ab(iii)

Reasons for designation:

This near endemic moth has a small distribution and is restricted to only 5 locations in the Georgia Basin in British Columbia. Much of its habitat has been destroyed and the quality of what remains is declining due to ongoing residential and commercial development, recreational activities, invasive or non-native species, and vegetation succession that has changed due to disruption of former fire regimes.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(iii)+2ab(iii) as it has a small EO (3600 km² for all known sites; 1881 km² for recent sites since 1975) and IAO (76 km² for all known sites; 20 km² for recent sites), the number of locations is 5 to 8 based on land ownership, and there is inferred continuing habitat decline based on continued habitat loss and fragmentation.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable as the number of mature individuals and their population trend is unknown.
Criterion D (Very Small or Restricted Total Population): Not applicable
Criterion E (Quantitative Analysis): Not applicable.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Island Tiger Moth

Grammia complicata

in Canada

2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Grammia complicata* (Walker 1865)

Classification:		
	Kingdom	Animalia
	Phylum	Arthropoda
	Order	Lepidoptera
	Superfamily	Noctuoidea
	Family	Erebidae
	Subfamily	Arctiinae
	Tribe	Arctiini
	Genus	Grammia
	Species	complicata

Synonyms: None

Type Specimens:
The Natural History Museum, London (male holotype); the type locality is Vancouver Island, British Columbia, Canada (Schmidt 2009).

English Name: Island Tiger Moth

French Name: Apantèse compliquée

Taxonomic Background and Similarities:
The former family Arctiidae has been subsumed as a subfamily within the family Erebidae (Zahiri *et al.* 2010). Island Tiger Moth, *Grammia complicata*, had been considered a subspecies of the Ornate Tiger Moth, *G. ornata* (Packard), but, based on morphological and molecular characters, Schmidt (2009) raised it to full species status. Compared to *G. ornata*, *G. complicata* has "much smaller eyes, pale yellow hindwing ground colour, extensively suffused hind wing markings, reduction of forewing bands (particularly the absence of the antemedial band), smaller more elongate forewings, and absence of the unlined forewing form", and "internally, most male specimens of *G. complicata* differ from those of *G. ornata* by the absence of the clasper" (Schmidt 2009). Schmidt (2009) summarizes previous literature discussing the taxonomic debate surrounding *G. complicata* and *G. ornata*.

Morphological Description

Adults

Island Tiger Moth is medium-sized (wingspan 32 to 40 mm) with variable wing patterns and colouration but without marked sexual dimorphism (Figure 1). The upper forewings are variable, but the basic colouration is dark brown-black interlaced with light orange-peach patterns resembling the species' wing venation. Conversely, some specimens are orange-peach interlaced with dark brown-black patterns. The hind wings are typically lighter than the forewings and orange-yellow-peach, with brown wing margins and brown dots towards the margins. The head, thorax and abdomen are also dark brown-black with peach-orange markings.

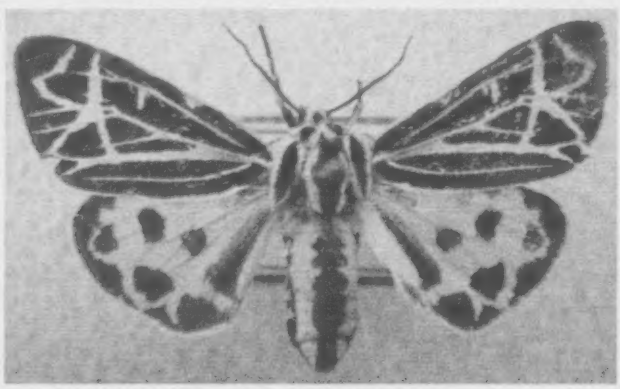

Figure 1. Island Tiger Moth (*Grammia complicata*) adult. Specimen from the University of British Columbia, Beaty Biodiversity Museum, Spencer Entomological Collection. Photograph by Jennifer Heron.

Eggs

Island Tiger Moth eggs have never been observed nor have they been described. The eggs of other *Grammia* species are typically circular, flattened at the base, and with shallow dimples or geometrical reticulations (Wagner 2009).

Larvae

Island Tiger Moth larvae have not been described. The larvae of other *Grammia* species are up to 6 cm long, hairy, and have black integument with lateral stripes of variable orange-brown-yellow (Wagner 2009).

Pupae

Grammia pupae tend to be smooth, shiny, somewhat bullet-shaped with a waxy bloom (Wagner 2009). Studies of Blake's Tiger Moth (*G. blakei*) showed that prior to pupation larvae form fragile cocoons covered with plant matter, within clumps of grass and loose soil, under cattle dung or within loose soil in shallow depressions (Byers 1988).

Specimens at the Royal B.C. Museum indicate larvae have been collected in B.C. and reared to adults; however, the associated field notes do not reveal additional information regarding morphological description of either larvae or pupae (Copley pers. comm. 2010).

Population Spatial Structure and Variability

No studies on population spatial structure and variability have been completed for Island Tiger Moth populations. With few exceptions, *Grammia* species do not reach high population densities (Byers 1988, 1989; Schmidt 2009). Most observations are of one or two individuals at a given site (Table 1 and 2). In the past ten years the species has only been collected or observed (photographed) four times at four separate and isolated sites: HMCS (Her Majesty's Canadian Ship) Quadra 19 Wing Comox Goose Spit; Savary Island; Nanoose Hill and Sandy Island Provincial Park (sites 1, 3 ,4 and 9 respectively in Table 2).

Table 1. Island Tiger Moth museum records.

Year	Month	Day	Collection Site Name	Site Number (Figure 2)	Is the habitat and site known and is the habitat likely still present	Museum or Collection	Notes
1895	June	18	no location		unknown site	UBC; E.H. Blackmore collection no. 978	
1896	March	18	Maple Bay	10	unknown site	RBCM	
1896	September	16	no site given		unknown site	UBC; E.H. Blackmore collection no. 978	
1900	July	17	Victoria			RBCM	
1903	June	7	Goldstream Provincial Park	7	habitat still present, unconfirmed presence	RBCM	
1910	July	10	Maple Bay	10	unknown site	RBCM	
1917	August	7	Royal Oak	11	unknown site	UBC; Ex. W. Downes collection donated 1958	
1917	July	11	Victoria	17	unknown site	UBC; E.H. Blackmore collection no. 978	
1918	June	16	Victoria	17	unknown site	UBC; E.H. Blackmore collection no. 978	

Year	Month	Day	Collection Site Name	Site Number (Figure 2)	Is the habitat and site known and is the habitat likely still present	Museum or Collection	Notes
1918	March	2	Victoria	17	unknown site	UBC; E.H. Blackmore collection no. 978	
1920	July	7	Duncan; Quamichan Lake	19	habitat still present, unconfirmed presence	RBCM	
1921	May	6	Saanich Dist.	12	unknown site	UBC; Ex. W. Downes collection donated 1958	
1924	July	9			unknown site	RBCM	
1929	June	26			unknown site	RBCM	
1933	July	17	Shawnigan Dist.	16	unknown site	UBC; Llewellyn Jones collection no. 1039	
1934	March	25				RBCM	ex larva
1934	March	25				RBCM	ex larva
1935	May	27	Sahtlam Dist.	15	unknown site	UBC; Llewellyn Jones collection no. 1039	
1949	June	14			unknown site	RBCM	
1951	May	21	Wellington	18	unknown site	UBC	
1953	June	9	Wellington	18	unknown site	RBCM	
1954	July	31	Saanich, Mt. Douglas	5	habitat still present, unconfirmed presence	RBCM	ex larva
1954	June	29	Saanich, Braefoot	13	unknown site	RBCM	Light trapped
1956	June	2	Saanich; Royal Oak	14	unknown site	RBCM	Light trapped
1956	June	21	Saanich; Royal Oak	14	unknown site	RBCM	
1956	May	31	Saanich; Royal Oak	14	unknown site	RBCM	ex larva
1957	June	19	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	
1957	May	19	Saanich, Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	ex larva
1957	May	28	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	
1957	May	29	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	
1957	May	30	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	ex larva
1958	June	15	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	ex larva
1958	May	20	Saanich, Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	ex larva
1958	May	24	Saanich, Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	ex larva; *Plantago lanceolata*
1958	May	24	Saanich, Royal Oak	14	unknown site	RBCM	Light trapped
1958	May	26	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	

Year	Month	Day	Collection Site Name	Site Number (Figure 2)	Is the habitat and site known and is the habitat likely still present	Museum or Collection	Notes
1958	May	26	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	
1958	May	25	Saanich; Royal Oak	14	unknown site	RBCM	
1961	June	21	Saanich; Royal Oak	14	unknown site	RBCM	
1961	May	29	Saanich; Observatory Hill	6	habitat still present, unconfirmed presence	RBCM	
1962	June	30	Saanich, Royal Oak	14	unknown site	RBCM	ex larva
1962	June	30	Saanich; Royal Oak	14	unknown site	RBCM	
1964	July	4	Spectacle Lake Park	8	habitat still present, unconfirmed presence	RBCM	
1975	July	6	Thetis Island, Str. of Georgia	2	habitat still present, unconfirmed presence	RBCM	
1977	May	3	Nanoose Hill	9	unknown site; habitat still present	RBCM	
1977	May	3	Nanoose Hill	9	unknown site; habitat still present	RBCM	
2000	June	8	Sandy Island	4	habitat still present, confirmed site	J. Troubridge	
2002	June	11	Savary Island	3	habitat still present, confirmed site	J. Troubridge	
2003	June	4	HMCS Quadra 19 Wing Comox Goose Spit	1	habitat still present, confirmed site	J. Troubridge	
2012	June	15?	Nanoose Hill	9	habitat still present, confirmed site	Mike Yip	
1933?	August	N/A	Victoria	17	unknown site	UBC; Ex. W. Downes collection donated 1958	
N/A	N/A	N/A	unknown site		unknown site	CNC	
N/A	N/A	N/A	unknown site		unknown site	RBCM	
N/A	N/A	N/A	Victoria		unknown site	UBC; E.H. Blackmore collection no. 978	

Table 2. Island Tiger Moth Sites in B.C.

Site Number	Site Name	Recent (record < 50 years old) or Historical (record > 50 years old)	Zone	Latitude	Longitude	First Year Recorded	Most Recent Year Recorded	Property Ownership	Habitat Trends & Threats and Site Status
1	HCMS Quadra 19 Wing Comox Goose Spit	Recent	10	361450	5502611	2003	2003	Federal	Habitat still present, confirmed site. IUCN-CMP Threats Goose Spit (polygon of habitat) is owned/managed by three groups: Comox First Nation, Comox Regional District (Parks) and federal Department of National Defense (HMCS Quadra 19 Wing Comox Goose Spit) The specific site where the moth was trapped is managed by HMCS Quadra although comparable habitat is throughout. A site management plan to minimize trampling has been developed for the portion managed by HMCS Quadra. Development is a threat (Appendix 1).
2	Thetis Island, Str. of Georgia	Recent (likely)	10	451000 (general)	5426000 (general)	1975	1975	Unknown, likely private	Habitat still present, unconfirmed collection site although high probability moth population is present. Large Gulf Island with a small human resident population that increases during summer months. Other than logging (does not apply to Island Tiger Moth habitat), the island is not likely to experience large-scale development. Succession, invasive species, impacts of a changing climate and gypsy moth spraying are important threats at this site.
3	Savary Island	Recent		370832	5533080	2002	2002	Private	Habitat still present, confirmed site. Open and natural area with homes and summer cabins on large lots. Active and engaged conservancy and community, interested in preserving both the ecosystems and natural environment. Nonetheless, development is a serious threat here and succession, climate change impacts and gypsy moth spraying are additional threats (Appendix 1).
4	Sandy Island Provincial Park	Recent		366378	5498026	2000	2000	Provincial (B.C. Parks)	Habitat still present, confirmed site. Some areas within the park are used by HMCS Quadra19 Wing Comox (DND) for sea cadet training during summer months. A site management plan has been created by DND to minimize impacts to sand dune and other fragile ecosystem values. Rec'n use - there are wooden camping pads on the island, although camping often occurs elsewhere. The island is visited often by boaters and recreational users. There is a large sandy beach and hiking trails traversing the island. Recreational development is a threat at this site and succession, climate change impacts and gypsy moth spraying are additional threats

Site Number	Site Name	Recent (record < 50 years old) or Historical (record > 50 years old)	Zone	Latitude	Longitude	First Year Recorded	Most Recent Year Recorded	Property Ownership	Habitat Trends & Threats and Site Status
5	Mount Douglas Park	Historical; habitat present		474600	5371200	1934	1954	Local Government (District Municipality of Saanich)	Habitat still present, unconfirmed presence of moth. Popular municipal park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry Oak and associated meadow ecosystems have experienced natural succession by both native and non-native plants (e.g., Scotch Broom). Numerous additional species at risk have been recorded from the park, and parks staff are aware of species at risk throughout park, and manage the Garry Oak habitats for conservation values.
6	Observatory Hill, Saanich	Historical; habitat present		469100	5374100	1957	1958	Federal	Habitat still present, unconfirmed presence of moth. Popular federally managed facility/park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry Oak and associated meadow ecosystems have experienced natural succession by both native and non-native plants (e.g., Scotch Broom). Numerous additional species at risk have been recorded from the park, and lands managers are aware of species at risk throughout park, and manage the Garry Oak habitats for conservation values.
7	Goldstream Provincial Park	Historical; habitat present		459200	5366700	1903	1903	Provincial (B.C. Parks)	Small amount of habitat still present, unconfirmed presence of moth. Popular provincial park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry Oak and associated meadow ecosystems have experienced natural succession, and in many cases the specific site of these habitats is unknown. habitat still present, but not much open meadow,
8	Spectacle Lake Provincial Park, Cowichan	Historical; habitat present		458300	5380700	1964	1964	Provincial (B.C. Parks)	Small amount of habitat still present, unconfirmed presence of moth. 67 ha provincial park close to urban areas, approximately 30km from Victoria, and with a variety of habitats and recreational facilities. Over time, the open Garry Oak and associated meadow ecosystems have experienced natural succession, and in many cases the specific site of these habitats is now unknown. The surrounding areas were logged in the 1960s, there are houses now surrounding the site, and suitable habitat on private land.
9	Nanoose Hill	Recent		413380	5457423	1977	2012	Federal, regional government, other surrounding areas unknown but likely private	Unknown collection site in 1977. Most recent sighting (2012) was reported by a naturalist and the land ownership may be federal or regional government. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
10	Maple Bay	Historical		455000	5407000	1896	1910	Unknown, likely private	Unknown collection site. Small amount of habitat may be present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.

Site Number	Site Name	Recent (record < 50 years old) or Historical (record > 50 years old)	Zone	Latitude	Longitude	First Year Recorded	Most Recent Year Recorded	Property Ownership	Habitat Trends & Threats and Site Status
11	Royal Oak	Historical		415600	5458500	1917	1917	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
12	Saanich Dist.	Historical		475370	5368464	1921	1921	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
13	Saanich, Braefoot	Historical		474400	5368600	1954	1954	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
14	Saanich, Royal Oak	Historical		471100	5371800	1958	1962	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
15	Sahtlam Dist.	Historical		440725	5403038	1935	1935	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
16	Shawnigan Dist.	Historical		452777	5388941	1933	1933	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
17	Victoria	Historical		475000	5365023	1900	1933?	Unknown, likely private	Unknown collection site. Habitat not likely still present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership. Six unknown sites labeled 'Victoria'
18	Wellington	Historical		424900	5451300	1949	1953	Unknown, likely private	Unknown collection site. Small amount of habitat may be present. Much of the area has experienced historical urban or agricultural development. Small and fragmented novel ecosystems are throughout area. Most of the area is in private ownership.
19	Duncan; Quamichan Lake	Historical		451300	5403700	1920	1920	Unknown, likely private	Unknown collection site. Small amount of habitat may be present. Area is surrounded by housing development, including the lakeshore. There are some agricultural areas within the vicinity. There is not much forested land (land that is not already cleared for agriculture) so agricultural conversion is more historical. Any trails or recreational areas are likely to be highly used, mostly for walking (including dog walking).

Designatable Units

Island Tiger Moth has one designatable unit within Canada. The species occurs entirely in the COSEWIC (2011) Pacific National Ecological Area and there is no information on population genetic structure among sites. There also are no data on discreteness or evolutionary significance among populations.

Special Significance

Island Tiger Moth inhabits two of the rarest ecosystems in B.C.: Garry Oak (*Quercus garryana*) ecosystems and the sparely vegetated sand ecosystems of southern Vancouver Island and Gulf Islands. There is no information that suggests the moth has an important cultural or economic role for First Nations people. However, there is literature on the cultural significance of plants associated with some of the habitats in which Island Tiger Moth occurs (Fuchs 2000; Page *et al.* 2011).

Island Tiger Moth is a near endemic in Canada with just one record from Washington State (WA). It is of interest to entomologists and taxonomists because of its apparent rarity. Tiger moth larvae (in general) are large, hairy and conspicuous and thus members of the public will often collect or photograph them (Copley pers. comm. 2010).

More than 115 provincial (red or bluelisted) species at risk inhabit the coastal lowlands of southeastern Vancouver Island and Gulf Islands (B.C. Conservation Data Centre 2012) with more than 84 of these species'assessed by COSEWIC (COSEWIC 2012). Two additional moth species that occupy similar habitat have been assessed by COSEWIC as Endangered: Edward's Beach Moth (*Anarta edwardsii* Smith) and Sand-verbena Moth (*Copablepharon fuscum* Troubridge and Crabo) (COSEWIC 2012).

DISTRIBUTION

Global Range

Island Tiger Moth has a limited range restricted to southeastern Vancouver Island and Gulf Islands of B.C., and the adjacent San Juan Islands, WA (Figure 2). A record from California (CA) (approximately 1200 km south of the WA record) (Opler *et al.* 2010), is a misidentification and is actually *G. edwardsii* (Schmidt pers. comm. 2011). Other specimens listed for WA as *G. complicata* by Ferguson (2000) and Opler (2010) are actually *G. ornata* (Schmidt 2009). Island Tiger Moth is geographically isolated from *G. ornata* by the Coast and Cascade mountains and broad areas of wet, coniferous forest (Schmidt 2009) and ranges from the southern interior of B.C. south through eastern WA, Oregon, and CA, and east through Idaho, Nevada, Wyoming, and Utah (Powell and Opler 2009; Schmidt 2009).

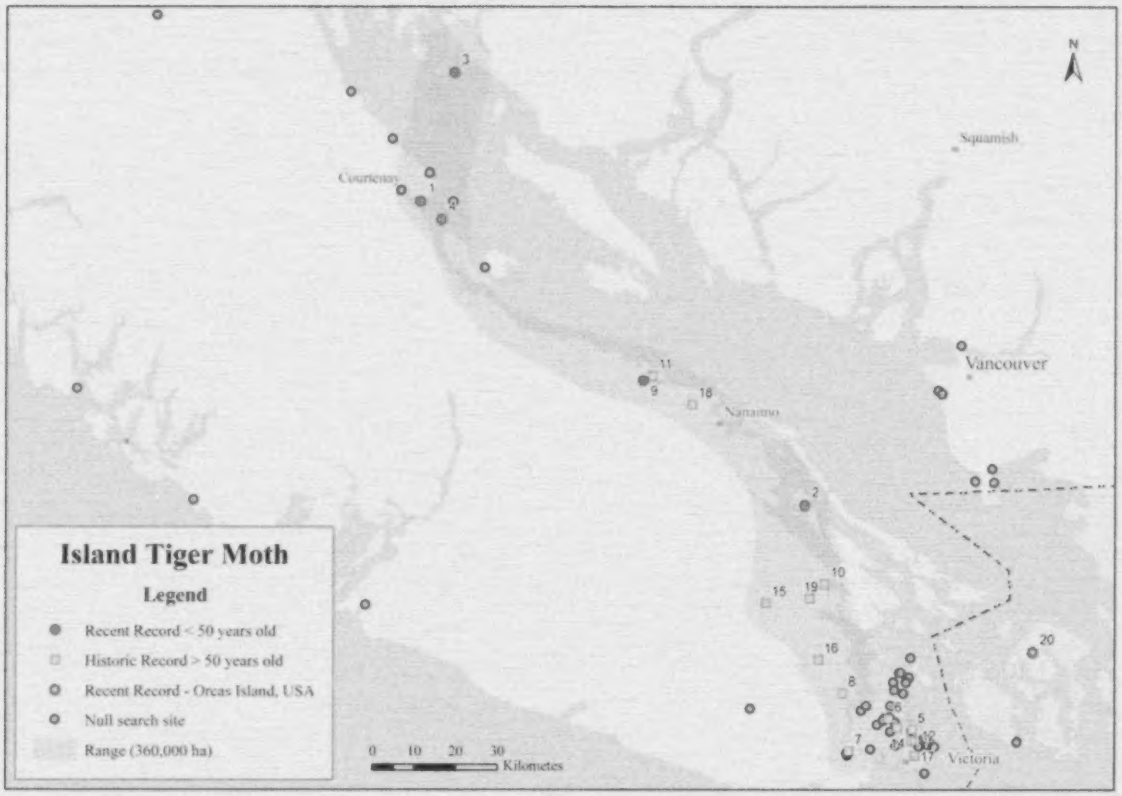

Figure 2. Global range (Site Numbers 1 – 20) and Canadian range extent of Island Tiger Moth including historical (square dots) and recent (round dots) capture sites (Table 1).

Canadian Range

The Canadian range of Island Tiger Moth is restricted to B.C. within the coastal lowland xeric habitats of southeastern Vancouver Island and adjacent Gulf Islands. Vancouver Island records are from the Greater Victoria area north to Comox (Table 1; Figure 2) with records from two Gulf Islands: Thetis Island and Sandy Island. Approximately 85% of the species' global range is in Canada (Crabo pers. comm. 2012; Schmidt pers. comm. 2012).

Island Tiger Moth records in B.C. date from 1895 to 2012 (Table 1), although the 1895 record does not have site collection information. There are 53 museum specimens or survey records for Island Tiger Moth (Table 1), which can be grouped into 19 sites (Table 2, Figure 2). In summary:

- Four recent sites (records less than 50 years old, confirmed collection information and habitat remains present at the site):
  - Site 1 HMCS Quadra 19 Wing Comox Goose Spit (hereafter called Goose Spit) (Figure 6 and 7); Site 3 Savary Island (Figure 8 and 9); Site 4 Sandy Island Provincial Park (Figure 10) and Site 9 Nanoose Hill.
- One recent site with vague site collection information but suitable habitat (Guppy pers. comm. 2011) remaining: Site 2 Thetis Island.
- Four historical sites (records more than 50 years old) with good present-day habitat and where the species is likely extirpated: Site 5 Mount Douglas Park; Site 6 Observatory Hill (Herzberg Institute of Astrophysics); Site 7 Goldstream Provincial Park; and Site 8 Spectacle Lake Provincial Park.
- Ten historical sites with vague site collection information where suitable habitat is not likely present in the general area (Sites 10 – 19).

Sites 1, 3 and 4 are less than 20 m above sea level (asl). Site 9 is under 240 m asl. All historical sites are under 500 metres asl.

Extent of Occurrence and Index of Area of Occupancy

Island Tiger Moth extent of occurrence is 3600 km^2 including historical and recent sites. If only the five recent sites are considered, the extent of occurrence is 1881 km^2, although this includes a large portion of ocean (Figure 2).

The index of area of occupancy (IAO; historical and recent) is 76 km^2 (based upon the minimum number of 2 km X 2 km squares that can cover all outlined populations in Figure 3). If only recent records are considered (sites 1, 2, 3, 4, 9) the index of area of occupancy is 20 km^2.

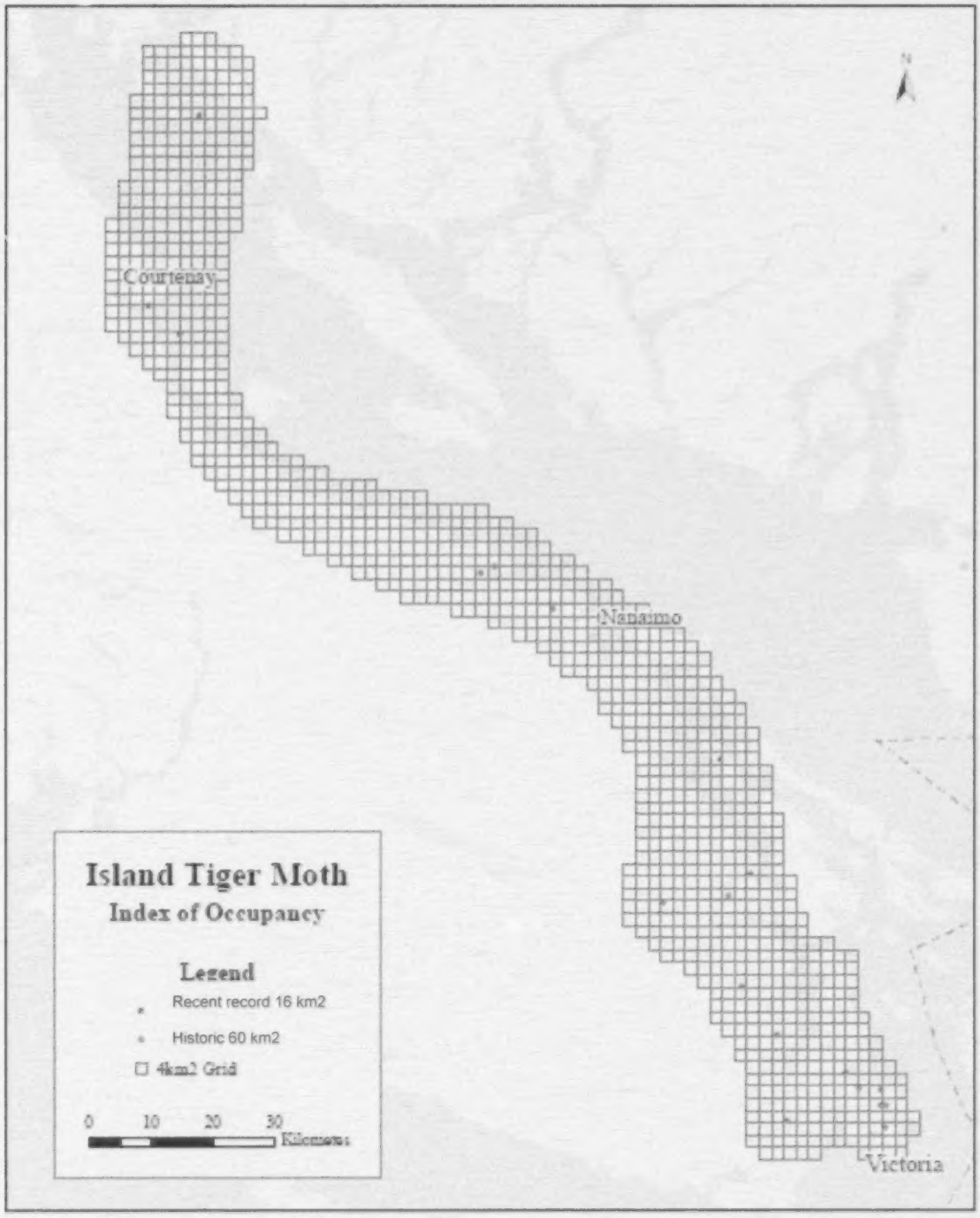

Figure 3. Island Tiger Moth index of area of occupancy estimated at 76 km^2 (recent and historical records). Index of area of occupancy for the four Canadian recent populations is 20 km^2.

In total, at most eight locations are considered for Island Tiger Moth based on development potential (land ownership) (see **Threats and Limiting Factors**).

Search Effort

From 2001 – 2011 there has been substantial ultraviolet light moth trapping within the potential range and habitat of Island Tiger Moth in B.C. (Table 3 and Figure 4) with a minimum of 420 trap nights over 83 separate sites within suitable potential Island Tiger Moth habitat. Some sites have been trapped multiple times over multiple dates and years with trapping directed specifically toward recording the presence of sand-dune moths (Page pers. comm. 2011). These moth surveys were completed during the status assessment process for additional endangered moths: Edward's Beach Moth (*Anarta edwardsii;* COSEWIC 2009) and Sand-verbena Moth (*Copablepharon fuscum;* COSEWIC 2003). Most trapping was within the potential flight period for Island Tiger Moth. During the past few years the weather in southeastern Vancouver Island has been colder and wetter into April and May (Island Tiger Moth flight season), pushing the flight season for some Lepidoptera later into the summer.

Table 3. Ultra-violet light trapping surveys within potential range and habitat of Island Tiger Moth 2000 - 2011.

Date Range	Trap Nights	Number of Sites	Historical or Known Collection Sites in this survey	Information Source
2000 - 2010	294	57	1 (Sandy Island Provincial Park)	N. Page pers. comm. 2011
2006	19	2	0	D. Holden pers. comm. 2011
2010	77	21	Mount Douglas Park	J. Heron pers. comm. 2011
2011	26	3	Observatory Hill	J. Heron pers. comm. 2011
2012	4	0	0	J. Heron pers. data 2012
Total	420	83	2	

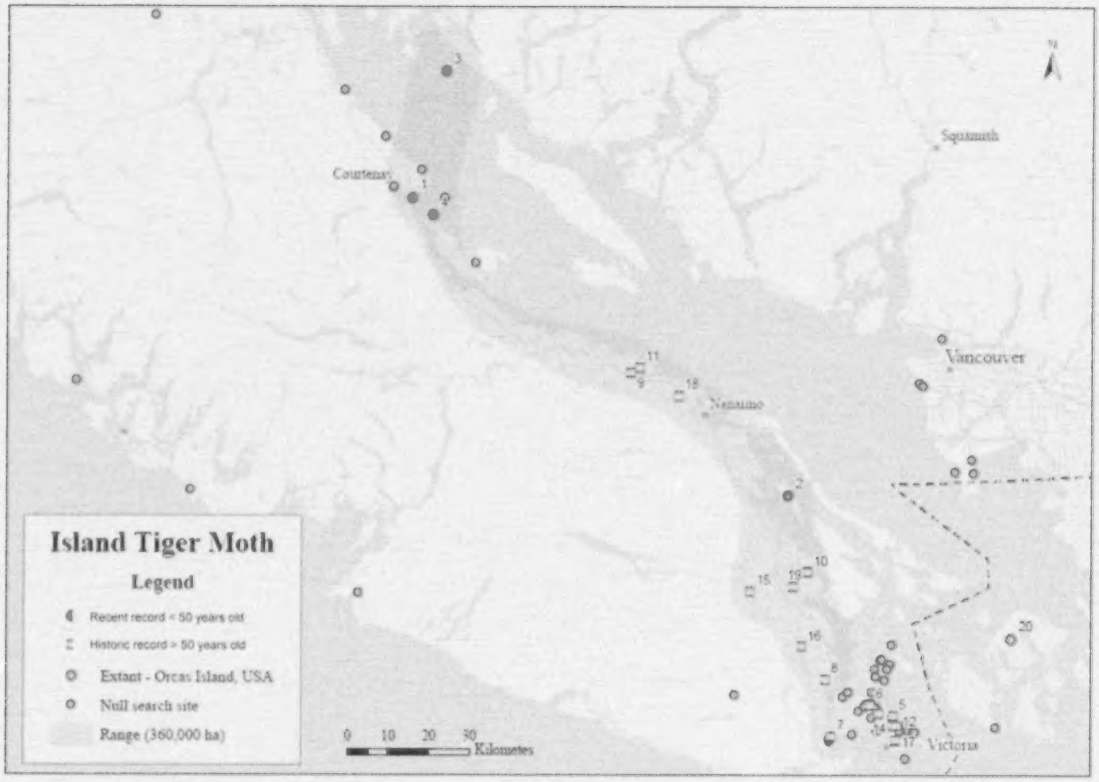

Figure 4. Island Tiger Moth trapping search effort (see Table 3). Note that due to the proximity of multiple traps within the same general vicinity, not all trapping sites are represented if within 500 metres of one another. Mapping completed by Byron Woods.

Figure 5. Gypsy Moth treatment areas 1979 – 2010. Note: data points are not exact and do not show the entire treatment area.See Table 6.

Historical sites with potential Island Tiger Moth habitat at Site 5 Mount Douglas Park and Site 6 Observatory Hill (Herzberg Institute of Astrophysics) were trapped in 2010 and 2011 respectively, without success. There is no recent trapping within the little Garry Oak habitat remaining at Site 7 Goldstream Provincial Park; and Site 8 Spectacle Lake Provincial Park has minimal suitable habitat due to succession.

Some moth experts believe ultra-violet light trapping is not the most effective method of capture for *Grammia* species (Byers 1988), although specimens have been captured in B.C. using this method (Page pers. comm. 2011)(Table 3). Morphological data (Schmidt 2009) and the scarcity of light-trap collected individuals (many historical specimens were reared and recent trap captures are of one or two individuals) suggest that the Island Tiger Moth may be day-active, and may not be strongly attracted to light. Conversely, the closely related *G. ornata* males are known to be nocturnal and attracted to ultra-violet light, while only the females are day active (Powell and Opler 2009). The three most recent records for the moth were captured with ultra-violet light traps: Site 1 Goose Spit (in 2000) (Page pers. comm. 2011); Site 3 Savary Island (Page pers. comm. 2010) (in 2000) and Site 4 Sandy Island Provincial Park (Troubridge and Woodward 2000).

Additional ultra-violet light moth trapping in additional open and grassy habitats, from lowland to higher elevation areas within the range of Island Tiger Moth has been carried out for academic research, but the moth has not been found (deWaard pers. comm. 2010; Holden pers. comm. 2011; Humble pers. comm. 2010).

Adult tiger moths (in general) are known to be difficult to find in the field (Byers 1988) and female *Grammia* species are rarely found or uncommon, likely due to their poor flight capabilities and heavy bodies (Wagner 2009). Regardless, butterfly and moth enthusiasts on southern Vancouver Island have continued to search the Garry Oak and associated ecosystems for at least ten years without finding the species (Holden pers. comm. 2007 – 2011; Tatum pers. comm. 2012). The most recent Island Tiger Moth record was an adult female photographed by a naturalist at Nanoose Hill (Site 9) in June 2012 (Yip pers. comm. 2013). Other *Grammia* species have been observed during these surveys (Tatum pers. comm. 2012). It is not possible to accurately quantify all search effort by lepidopterists; however the effort has been substantial. This striking, attractive genus has been photographed and noted in the "invertebrate [email] alerts" posted by the Victoria Natural History Society (Tatum pers. comm. 2012). No incidental collections of Island Tiger Moth are known from provincial museums (Copley pers. comm. 2010; Needham pers. comm. 2010).

Hand searching for adults and larvae for 2.5 hours in April 2004 resulted in four Nevada Tiger Moth, *G. nevadensis* caterpillars being found at Mount Douglas Park (Schmidt pers. comm. 2012). Eight person hours search at the same site in 2010 (Figure 11) resulted in no *Grammia* larvae being found (Heron pers. comm. 2010).

Butterfly surveys throughout southern Vancouver Island and Gulf Islands have not specifically included moths although surveyors would have likely noted Island Tiger Moth during surveys (Table 4) (Lilley pers. comm. 2011; Page pers.comm. 2012). Evidence of collecting effort on the Qualicum and Englishman river estuaries would help resolve large apparent gaps in distribution.

Table 4. Recent butterfly surveys that included habitat for Island Tiger Moth. If Island Tiger Moth is not highly attracted to ultra-violet light traps, alternate survey methods would include visual daytime surveys. Although visual surveys may not be optimal for moths, surveyors did encounter other large moth specimens during these surveys, and would have noted *Grammia* (all species) if encountered.

General Survey Site and Date	Person Hours searched during Island Tiger Flight Season	Distance Searched	Island Tiger Moth observations	Historical Sites included in this survey	Report Citation
2001, Southern Vancouver Island and Gulf Islands	N/A	N/A	None	Unknown	Guppy and Fisher 2001
2007, Denman and Hornby islands April 28 – June 13 (private and public land)	168.4 hours	288.1 km	None	N/A	Page *et al.* 2007

General Survey Site and Date	Person Hours searched during Island Tiger Flight Season	Distance Searched	Island Tiger Moth observations	Historical Sites included in this survey	Report Citation
2007, Denman Island Settlement Lands	N/A	N/A	None	N/A	Guppy, Kroeker and Webb 2007
2007, Gulf Islands National Park Reserve (May through August)	90.7 hours	18 sites (total area 1589 ha); 4 visits to each site	None	N/A	Fenneman 2008
2008, Courtenay, Comox, Denman island and Hornby island, May 15 – June 14 (private and public land)	35.2 km on Vancouver Island; 29.1km on Denman Island; 8.2 km on Hornby Island	72.5 km (58.6km by foot; 13.9km by car)	None	N/A	Page *et al.* 2008a
2008, Gulf Islands National Park Reserve (federal) May through August	N/A	18 sites (total area 1589 ha); 4 visits to each site	None	N/A	Guppy 2008
2008, Southern Vancouver Island May 4 – May 17, 2008 (private land)	59.3 hours	95.6 km	None	N/A	Page *et al.* (2008b)
2009, Courtenay, Comox and other areas on southern Vancouver Island 2009 (private land) May 21 – August 26, 2009	104.2 hours	380.7 km	None	N/A	Page, Lilley and Heron 2009
2009, Denman Island 2009 (private land)	17 days, 2 – 3 surveyors per day	NA ~ 809 ha area	None	N/A	J. Heron, unpublished data
2009, Lepidoptera surveys in Victoria Parks May 30 – 31, 2009	6.2 hours	20.8 km through 8 parks in the City of Victoria	None	N/A	Page and Lilley 2009
2010, Butterfly Surveys in southeastern Vancouver Island	106.2 hours	332.2 km	none	N/A	Page, Lilley and Heron 2010

There is little survey information on Island Tiger Moth in WA (Potter pers. comm. 2010; Thomas pers. comm. 2010; Crabo pers. comm. 2012). Ultra-violet light surveys and hand searching by moth experts within the San Juan Islands have not recorded the species except at Orcas Island (Crabo pers. comm. 2012).

HABITAT

Habitat Requirements

Grammia species (in general) are associated with dry and sparsely treed habitats including meadows, grasslands, open forest, rocky slopes, dunes, sparsely vegetated habitats and gravely or rocky substrates (Schmidt 2009). *Grammia* species typically do not inhabit closed canopy forests (Schmidt pers. comm. 2011). Most western North American *Grammia* species occur at low to mid elevations, in areas of poor or shallow soils, sand hills, beaches and other similar habitats (Schmidt 2009). Island Tiger Moth has been collected in these same dry and sparsely treed habitats in B.C., predominantly open moist to dry meadows; open deciduous woods and grassy areas adjacent to open sand dune habitats. These habitat types can be characterized as 1) Garry Oak and associated ecosystem habitats and 2) sparsely vegetated habitats.

1) Garry Oak and associated ecosystems

Garry Oak ecosystems occur on the eastern side of Vancouver Island, from the greater Victoria area north to the Comox area; throughout the southern Gulf Islands as far north as Savary Island in the Strait of Georgia; and two isolated pockets of habitat at Sumas Mountain and near Yale, in the lower Fraser Valley (Garry Oak Ecosystems Recovery Team 2011). Garry Oak ecosystems have been described in detail by Roemer (1962) and Erickson (1993, 1995) and are part of the Coastal Douglas-fir biogeoclimatic zone (B.C. Ministry of Forests, Lands and Natural Resource Operations 2012).

Four historical collection records are from present day Garry Oak habitats (Table 2, Figure 2): Mount Douglas Park (site 5); Observatory Hill (Herzberg Institute of Astrophysics) (site 6); Goldstream Provincial Park (site 7) and Spectacle Lake Provincial Park (site 8)(B.C. Conservation Data Centre 2012). Portions of Savary Island (site 3) are considered Garry Oak ecosystems (GOERT 2011).

The most recent record at Nanoose Hill (Site 9) is considered Garry Oak habitat. The specimen was photographed within an open mossy meadow adjacent to a patch of small conifers and Arbutus trees (*Arbutus menziesii*) (Yip pers. comm. 2013).

2) Sparsely vegetated habitats

Three recent records of Island Tiger Moth (Table 1) are from lowland sparsely vegetated grassy habitats within the taller and more established vegetation adjacent to sandy beach and dune habitats (Page pers. comm. 2011). Island Tiger Moth was caught on Savary Island (in 2003) (site 3) in longer grassy habitat adjacent to open exposed sand dunes (Figure 8 and 9) (Page pers. comm. 2010). The moth was caught in similar habitat at Goose Spit (site 1)(Figure 6 and 7) (Page pers. comm. 2010) and Sandy Island Provincial Park (site 4)(Figure 10) (Page pers. comm. 2010).

Figure 6. Island Tiger Moth habitat at HMCS Quadra 19 Wing Comox Goose Spit. Zone 10 Easting 361450 Northing 5502611. Photograph by Nick Page.

Figure 7. Island Tiger Moth habitat at HMCS Quadra 19 Wing Comox Goose Spit. Zone 10 Easting 361450 Northing 5502611. Photograph by Nick Page.

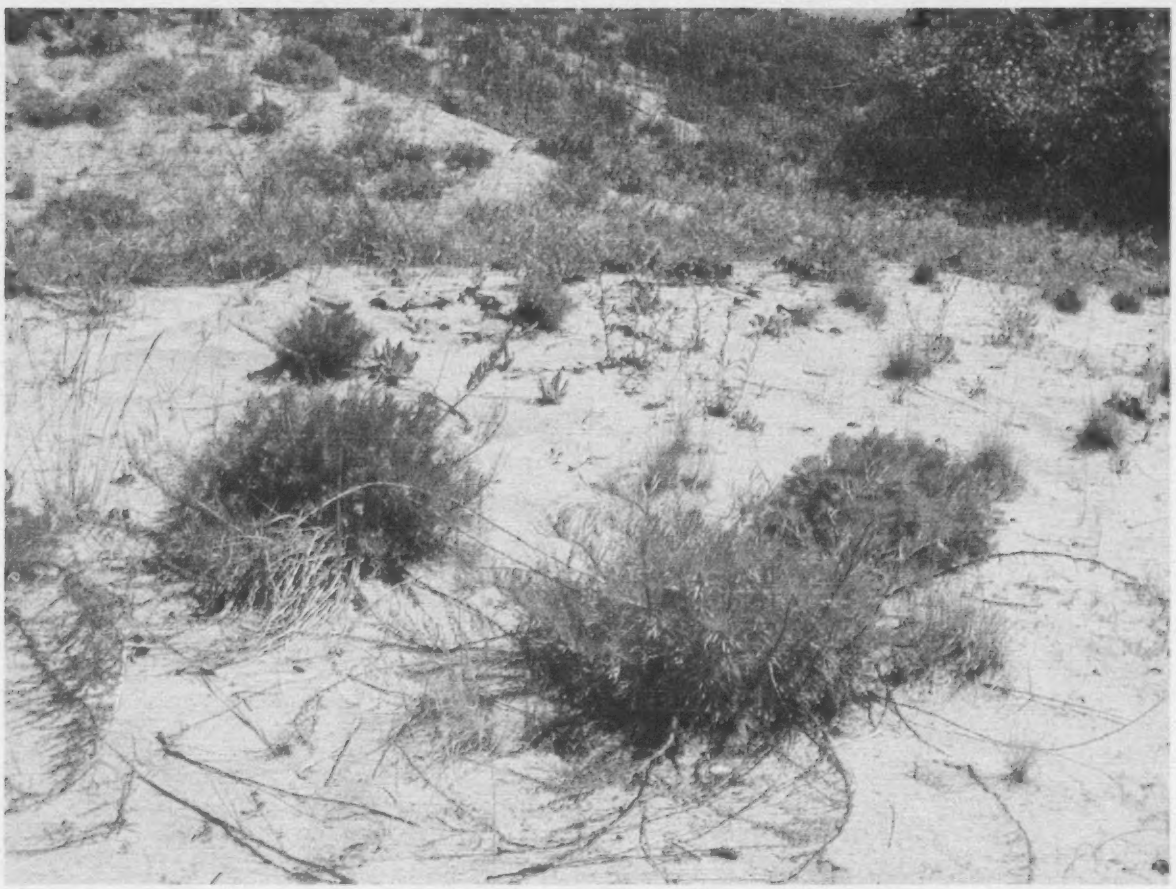

Figure 8. Island Tiger Moth habitat at Savary Island, May 31, 2005 (date of photograph is not the Island Tiger Moth collection date). Specific UTM of photograph unknown but UTM of moth Zone 10 Easting 370832 Northing 5533080. Photograph by Carmen Cadrin.

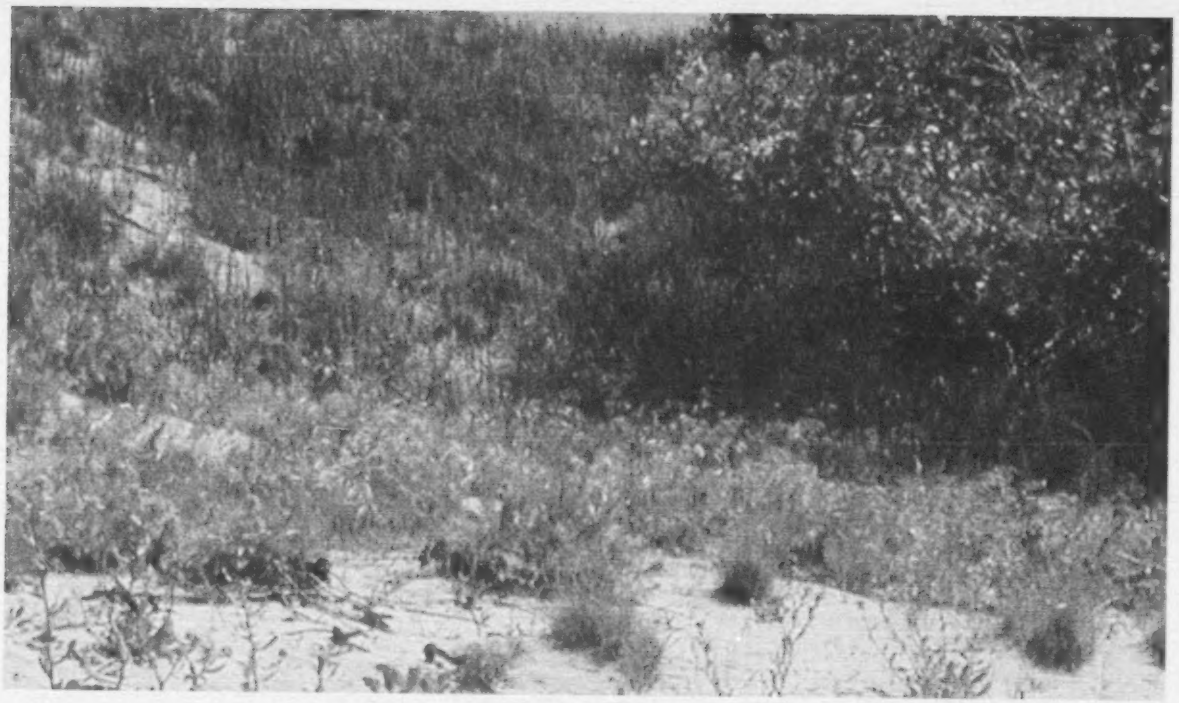

Figure 9. Island Tiger Moth habitat at Savary Island, May 31, 2005 (date of photograph is not the Island Tiger Moth collection date). Specific UTM of photograph unknown but UTM of moth Zone 10 Easting 370832 Northing 5533080. Photograph by Carmen Cadrin.Photograph by Carmen Cadrin.

Figure 10. Island Tiger Moth habitat at Sandy Island Provincial Park, August 8, 2007 (although moth not captured on this date). Zone 10 Easting 366378 Northing 5498026. Recent site for Island Tiger Moth (collected in 2000)(Troubridge and Woodward 2000). Photograph by Jennifer Heron.

Figure 11. Mount Douglas Park, Saanich. Historical record for Island Tiger Moth, although specific collection site within park is unknown. Habitat sampled for Island Tiger Moth with null results August 17, 2010 (light trapping).Zone 10 Easting 474600 Northing 5371200.Photograph by Darren Copley.

Larval host plants

Grammia species are generalist herbivores, consuming a wide range of low-growing plant species (Ferguson 1985; Byers 1988; Schmidt 2009). Studies of Blake's Tiger Moth (*G. blakei*) document larval feeding on both mono- and dicotyledonous plants including grasses (Byers 1988). Island Tiger Moth likely has similar feeding preferences. An Island Tiger Moth larva collected in B.C. on May 24, 1958 is documented as feeding on introduced English Plantain (*Plantago lanceolata*) according to the associated field notes (George Hardy's field notes housed at the Royal B.C. Museum) it is unclear if the larva fed on this plant in captivity, or was observed feeding upon it in nature as George Hardy liked to rear caterpillars (Copley pers. comm. 2010).

Habitat Trends

Most low-elevation ecosystems throughout the known range of Island Tiger Moth on southern Vancouver Island have been extensively modified over the past 100 years. Cumulative impacts from intensive recreational activity, construction of urban and commercial buildings, roads and transportation corridors, the spread of invasive plants, and natural forest succession have contributed to the overall decline in the quantity and quality of the ecosystems from which Island Tiger Moth has been recorded.

The most recent information on habitat trends for these sparsely vegetated coastal sand ecosystems and Garry Oak and associated ecosystems comes from the Sensitive Ecosystem Inventory project on southeastern Vancouver Island carried out between 1993 and 1997 and again in 2002 (Ward *et al.* 1998). Potential Island Tiger Moth habitat assessed includes woodland ecosystems (2.6% lost between 1993 – 2002) and sparsely vegetated habitats such as spits, dunes and cliffs (1.4% lost between 1993 – 2002) (Canadian Wildlife Service and B.C. Ministry of Environment 2004; Kirkby and Cake 2004). Sparsely vegetated habitats cover less than 0.1% (335 ha) of the east coast of Vancouver Island and adjacent Gulf Islands and are the rarest of the sensitive ecosystem types. Most of the ecosystem units are small, measuring less than five hectares. Within the region, there are 26 coastal spits (111.3 ha), 8 dunes (39.5 ha) and 52 inland cliffs and bluffs (184.2 ha) (Ward *et al.* 1998). Unmodified examples are extremely rare as most are close to human population centres and thus highly disturbed by introduced species such as Scotch Broom (*Cytisus scoparius*) and non-native grasses, recreational trails, fragmentation and other impacts (Ward *et al.* 1998) (see **Threats and Limiting Factors**).

Recent aerial photography suggests there is little to no suitable habitat in at least eleven of the fourteen sites where Island Tiger Moth records are considered historical (> 50 years old). Initially, these local areas would have been converted to agriculture (up until the mid-1960s). Since then, conversion has been to housing and infrastructure development (see Threats). Historical sites are shown in Table 2 and Figure 2.

Vegetation stabilization may contribute to the decline in number and connectivity between sites available to Island Tiger Moth. Overall, open sparsely vegetated plant communities are susceptible to the colonization of invasive plants (see Threat 8.1 Invasive non native/alien species). Habitat trends are therefore clearly negative in both quality and quantity.

Much historical Garry Oak ecosystem habitat has been lost to development or is degraded due to invasive species and human activities (see **Threats and Limiting Factors**). Large Garry Oak trees are often preserved during development (both historical and recent) but the natural plant communities under these trees are no longer intact (Lea 2006, Garry Oak Ecosystems Recovery Team 2011).

Lea (2006) mapped historical Garry Oak ecosystems, focusing on the five major geographic areas known to contain them (greater Victoria, Cowichan Valley, Comox Valley and surrounding areas, Nanaimo and the Nanoose Bay area, as well as Salt Spring Island and Hornby Island). Mapping was completed for both parkland and scrub oak ecosystem types (see **Habitat**) at a 1:20,000 scale and based on the original land surveys completed in the 1850s and 1860s, and recent forest stand history field observations. The historical ecology of an area was based on information in Egan and Howell (2001). This study concluded less than ten percent of the original Garry Oak ecosystem within the study area remains on southeastern Vancouver Island (Lea 2006). Land clearing for urban, rural and agricultural development started in the 1840s, targeted rich and deep soils and has resulted in the loss of 98.5% of the Parkland Garry Oak ecosystem type (Lea 2006). More of the Scrub Oak ecosystem type remains, primarily because it occurs on shallow soils, rocky bluffs and areas that are difficult to develop for agricultural and other purposes (Lea 2006).

Historically, low intensity, frequent fire played an important role in the maintenance of Garry Oak ecosystems (Daubenmire 1968, Agee 1993, McPherson 1997, Fuchs 2000). Before European contact, fires originated with lightning and First Nations cultural burning practices within the region (see Fuchs 2000 for a literature review). Following European contact, cultural burning practices were banned and fire suppression has been in place for over 150 years. Fire exclusion has resulted in gradual changes to the plant community composition (McCoy 2006).

The introduction and gradual spread of non-native plants has led to further decline in the quality and composition of Garry Oak plant communities (see **Threats and Limiting Factors**). Invasive plants dominate most of the remaining Garry Oak ecosystems. Habitat remnants that contain near-natural Garry Oak ecosystem understory vegetation comprise less than five percent of the original ecosystem (Lea 2006; Garry Oak Ecosystems Recovery Team 2011).

Climate change may allow the expansion of the area within which Garry Oak ecosystems are found on southern Vancouver Island (Hebda 2004). It is likely the Garry Oak is able to expand its geographic range, but less likely the understory plant communities will be able to expand their ranges (Lea 2006) (see **Threats and Limiting Factors**).

BIOLOGY

Life Cycle and Reproduction

The life history of Island Tiger Moth has not been studied (see Table 5). Museum records (Table 1) show the flight period in B.C. ranging from May to late July. Ten museum specimens (Table 1) were originally collected as larvae and reared to adulthood (museum records indicate the larval collection date and were excluded from the flight period time frame). There is no accompanying specimen information regarding the larval instar collected, duration to pupation or date of adult moth emergence (Royal B.C. Museum records, Table 1). There is no notable difference in adult capture dates depending upon latitude. *Grammia* adults (in general) are short-lived (3 weeks), have nonfunctional mouthparts and do not eat (Schmidt 2009).

Table 5. Yearly life cycle of Island Tiger Moth in B.C. (unconfirmed).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Eggs				—	—	—						
Larvae			.....	.....	.....	.....	.....	.....	.....			
Dormant Larvae	—	—	—					—	—	—	—	
Pupae (brief)			—	—								
Adults				—	—	—	—					

Studies on another Tiger Moth species, *G. geneura*, document 100 – 1000 eggs laid (Singer 2000) in non-specific areas amongst ground litter and dead vegetation (Singer 2000; Schmidt 2009; Wagner 2009). Island Tiger Moth eggs likely hatch shortly after oviposition and larvae continue to grow until late August and early September. Most temperate tiger moths overwinter as larvae and resume feeding the following spring (Byers 1988; Schmidt 2009; Wagner 2009). Island Tiger larvae have been collected as early as March 25th at Site 5 Mount Douglas Park (see Table 1). Pupation likely occurs in late April to mid May. Larvae likely pass through six or seven instars before pupation (Byers 1988).

Physiology and Adaptability

There is no information on the physiology or adaptability of Island Tiger Moth. Tiger moth eggs, larvae and adults are known to contain pyrrolizidine alkaloids sequestered through feeding upon plants also containing these chemicals (Hartmann 2009). The result is a chemical defense system against predators. Tiger moth larvae are known as generalist feeders (Wagner 2009) and thus it is unknown at what levels of effectiveness Island Tiger Moth sequesters plant compounds.

Dispersal and Migration

Island Tiger Moth is not migratory and the maximum dispersal distance is unknown. However, because of the small wing area and heavy bodies, females are not expected to fly far (Schmidt pers. comm. 2011). Male Blake's Tiger Moth are considered good fliers, and may fly longer distances in search of females in response to pheromones (Byers 1989). Island Tiger Moth males may have similar dispersal capabilities. Information on the dispersal distances of other tiger moths suggest flight capabilities of a "a few hundred yards" (e.g., *Cycnia inopinatus*, Bess 2005).

Interspecific Interactions

Both larvae and adults are likely preyed opportunistically by birds and bats but predation may be limited by pyrrolizidine alkaloid toxicity (see studies on other *Grammia* species including Weller *et al.* 1999; Singer and Stireman 2003; Bernays and Singer 2005; and Hartmann *et al.* 2005; Schmidt 2009). Parasitoids could attack all Island Tiger Moth life stages, although there are no confirmed records. Studies on *G. geneura* documented more than fourteen parasitoid species, mostly polyphagous tachinid flies (Stireman and Singer 2002). Further information on parasitism in *Grammia* species is summarized in Schmidt (2009).

Larval feeding likely damages food plants but is unlikely to cause plant mortality, although a few *Grammia* species (e.g. *G. blakei*) are considered occasional pests (Byers 1988; 1989).

POPULATION SIZES AND TRENDS

There is no detailed information on Island Tiger Moth population sizes in B.C. However, the sparse records suggest that the species has never been common anywhere within its range. The population size in WA is also not known (Potter pers. comm. 2010; Thomas pers. comm. 2010; Crabo pers. comm. 2012).

Historically, Island Tiger Moth likely exhibited a more extensive metapopulation structure within suitable maritime meadow and open grassy sparsely vegetated sand ecosystem habitat throughout its known range in southwestern B.C. Urban and agricultural development, combined with natural succession and fire suppression, has resulted in fragmentation declines of these habitats and likely led to increased isolation of moth populations, decreasing the probability that habitats are recolonized following extirpation. The genetic consequences of the isolation of small populations are well known (e.g. Saccheri *et al.* 1998).

Sampling Effort and Methods

Surveys have primarily been by nocturnal ultra-violet light trapping in suitable habitat with the main objective of confirming historical records and discovering habitat information and new sites for the species (Table 3). Low capture numbers, combined with this methodology does not enable population size to be determined.

Abundance

Collection records show that individuals have been seen only as singletons (Table 1; B.C. Conservation Data Centre 2012). Most *Grammia* species are not recorded in high abundance. The species is at best uncommon.

Fluctuations and Trends

There is no information on population fluctuations or trends for Island Tiger Moth. This species has been rarely collected, and it can be assumed it likely doesn't experience large fluctuations in population size (Byers 1988, 1989; Schmidt 2009).

Rescue Effect

The closest known confirmed Island Tiger Moth site is on Orcas Island, in the San Juan Islands, WA (Figure 4) (Crabo pers. comm. 2012). Orcas Island is approximately 60 km (straight distance) from the closest habitat at Thetis Island (site 2) and approximately 60 km (straight distance) from Sandy Island Provincial Park (site 4). The nearest potential Island Tiger Moth habitat in B.C. occurs at Sidney Spit (~ 22 km), James Island (near Sydney, ~23 km), Saturna Island (~19 km) and Cordova Spit (near Sydney, ~ 25 km). No records of Island Tiger Moth are known from these sites despite moth trapping (Figure 4). Natural dispersal among these areas by females is likely impossible. Rescue from the United States is highly unlikely.

THREATS AND LIMITING FACTORS

The International Union for Conservation of Nature-Conservation Measures Partnership (IUCN-CMP) threats calculator was used to classify and list threats to Island Tiger Moth (Salafsky *et al.* 2008; Masters *et al.* 2009). The overall Threat Impact for Island Tiger Moth is Very High (see Table 6 for results). Major threats include residential and commercial development, recreational activities, and succession from both introduced and native species.

Residential and commercial development (IUCN – CMP Threat 1.)

Potential Island Tiger Moth habitats (both Garry Oak and sparsely vegetated sand ecosystem habitats) throughout southeastern Vancouver Island and Gulf Islands are threatened by urban and rural land conversion, and the subsequent fragmentation of the existing natural plant communities. Many of these remaining habitats are privately owned and/or within close proximity to urban areas, and thus subject to further development pressure (GOERT 2011) (see Habitat Trends).

Housing and urban areas (Threat 1.1)

This threat is directly applicable to site 3 Savary Island. The habitat on Savary Island spans property owned by two landowners. One landowner would like to develop the property into smaller lots for housing; the other landowner would like the property to become a conservancy area with no further housing or urban development. At present there is no stipulation as to what spatial area(s) housing development can occur on the property and there is a legal dispute between landowners that is currently within provincial court and has yet to be resolved. Savary Island (in general) has been subject to ongoing development pressure for many years (Savary Island Land Trust 2010) and ongoing incremental housing development is occurring on small habitat parcels throughout the island.

Commercial and industrial areas (Threat 1.2)

This threat is directly applicable to Goose Spit (site 1). Island Tiger Moth was captured on the property managed by HMCS Quadra 19 Wing Comox; however, the sand ecosystem habitat at the greater Goose Spit area spans three separate land owners/managers: i) HMCS Quadra 19 Wing Comox (federal government, Department of National Defence), ii) Comox Regional District Parks; and iii) Comox First Nation. There are plans to develop the portion of Goose Spit owned by Comox First Nation into a marina with associated commercial buildings, infrastructure, and possibly a casino. The road infrastructure to access the portion of the spit owned by Comox First Nation crosses through the other two landowners' property (see Threat 4.1). There are ongoing negotiations that involve all levels of governments regarding this proposal. The other two land ownerships are not at risk of commercial or industrial development.

Tourism and recreational areas (Threat 1.3)

The threat of development of tourism and recreational infrastructure is applicable to three sites (1, 2, 4), although the scope, severity and impact of this threat are variable between each site.

In the past ten years, the whole of Goose Spit (site 1) has experienced small (< 100 m^2) habitat loss from expansion of washroom facilities within Comox Regional District Park; expansion of a cadet obstacle course at HMCS Quadra 19 Wing Comox Goose Spit (< 100 m^2); and all-terrain vehicle use throughout all of Goose Spit.

Conversion of sand ecosystem environments has occurred at site 4 Sandy Island Provincial Park (e.g., campgrounds) and site 1 Goose Spit Regional Park (e.g., parking areas and washroom facilities). Expansion of beach areas (e.g., Goose Spit Regional Park) and destruction of sand ecosystems for marine developments (e.g., Site 1 HMCS Quadra 19 Wing Comox Goose Spit) continue to pose threats to habitat. Sandy Island Provincial Park has increased the number of tent platforms available for overnight camping. Past conversion of sand habitats has occurred due to the development of military training facilities (e.g., buildings, training apparatus, and parking areas) at the portion of Goose Spit managed by HMCS Quadra 19 Wing Comox and both recreation and military training at Sandy Island Provincial Park (cadets practise manoeuvres at the park). Where the two are in conflict, national security considerations clearly supersede those governing species at risk (B.C. Invertebrates Recovery Team 2008).

Agriculture and aquaculture (Threat 2.)

Livestock farming and ranching (Threat 2.3)

Specific site collection information for ten of the historical sites is unknown, but was likely from within agricultural or meadow habitats that were grazed by domestic livestock or cleared for agricultural farming. This threat was likely more apparent historically than at present, although may continue to impact small patches within unchecked habitats throughout southeastern Vancouver Island and especially within the Gulf Islands.

Transportation and service corridors (Threat 4.)

Roads and railroads (Threat 4.1)

The threat of road expansion is present at two sites: Goose Spit (site 1) and Savary Island (site 3).

At Goose Spit, the main access road travels through a narrow portion of habitat within Comox District Regional Park which is periodically flooded from ocean tides during large storms. There is ongoing pressure from private citizens (who use the park) to expand this portion of the roadway and provide pull-outs for vehicles. The road then becomes gated as it enters the portion of Goose Spit managed by HMCS Quadra 19 Wing Comox, where it also travels through natural dune habitat and into the area of the spit managed by Comox First Nation where the road ends. This gate prevents unauthorized traffic from entering the site; however, there is ongoing pressure to remove this gate and if further commercial development proposals are approved (on the portion of the spit governed by Comox First Nation – see Threat 1.2) this road would likely be paved and further access by the public permitted.

Human intrusions and disturbance (Threat 6.)

Recreational activities (Threat 6.1)

The threat of ongoing recreational activities is applicable to three Island Tiger Moth sites. Sandy Island Provincial Park (site 4) and Goose Spit (site 1) continue to experience impacts from park use (e.g., trampling of plants, garbage, pet use, illegal camping). Sandy Island Provincial Park is a popular boating and tourist destination, and has facilities for overnight camping (e.g., wooden camping platforms for tents) and unpermitted camping on natural habitats is ongoing. HCMS Quadra 19 Wing Comox Cadets is also permitted to host summer beach training exercises for approximately two weeks per year in one area of Sandy Island Provincial Park. HCMS Quadra 19 Wing Comox has developed a site management plan that minimizes impacts to fragile sand ecosystems from training exercises. Savary Island (site 3) is a popular summer tourist destination, mainly due to the long stretches of natural sandy beach available for sun bathing, sand castles and walking. Impacts from use are similar to those on Sandy Island Provincial Park and Goose Spit. Nanoose Hill (site 9) is also a recreational area, although impacts are considered negligible at this time.

Invasive and other problematic species and genes (Threat 8.)

Invasive non-native/alien species (Threat 8.1)

Many introduced plants occur throughout both Garry Oak and coastal sand ecosystems. Introduced plants out-compete the lower growing herbaceous plants which are potential host plants for Island Tiger Moth. Invasive species legacy (resulting long-term ecosystem impacts from prolonged invasive species growth) includes increasing nitrogen availability in the soil, which may encourage exotic species growth in native grasslands (Huenneke *et al.* 1990; Maron and Conners 1996 as cited by Rook *et al.* 2011).

Plants such as Scotch Broom, and exotic grasses such as Cheatgrass (*Bromus tectorum*), European Beach Grass (*Ammophila arenaria*), Orchardgrass (*Dactylis glomerata*), Common Velvet Grass (*Holcus lanatus*), Soft Brome (*Bromus hordeaceus*) and Rattail Vulpia (*Vulpia myuros*), have accelerated dune stabilization at the most recent known Island Tiger Moth sites (COSEWIC 2009). For example, Scotch Broom is widespread, known to fix nitrogen in low fertility sand soils and is known to change vegetation and soil structure (Haubensak and Parker 2004) and rapidly take over sand-dominated areas (COSEWIC 2009). Scotch Broom is associated with suppressed native species richness (Rook *et al.* 2011). Scotch Broom control is ongoing at Goose Spit (site 1), Mount Douglas Park (site 5), and Observatory Hill (site 6).

The threat of non-native invasive species is applicable to three sites (site 1, 3 and 4). Within the portion of property at Goose Spit (site 1) managed by HMCS Quadra 19 Wing Comox, a large area of Scotch Broom was recently removed, with the objective of recovering some of the sand ecosystem habitat and simultaneously removing cover being used by introduced rabbits (Naish pers. comm. 2010). Comox Regional District controls some Scotch Broom, although there is not much invasion within this part of the property (Albert pers. comm. 2010).

Numerous invertebrate predators have been introduced to B.C. as biological control agents (targeting invasive plant species) and have unknown impacts to Island Tiger Moth populations. Insect parasitoids, such as tachinid flies (Family Tachinidae) have been introduced as biological control agents for various pests (Tothill 1913). For example, *Cyzenis albicans* was introduced to southwestern B.C. to control Winter Moth (*Operophtera brumata*), a pest of Garry Oak, fruit trees and many other plants (Cannings and Scudder 2005). *Compsilura concinnata* is considered the most polyphagous of all tachinids with over 200 recorded hosts. The species was introduced from Europe, mainly to control Gypsy Moth (*Lymantria dispar*) in eastern North America, but has spread west to the Pacific coast. This tachinid attacks many insects, from *Pissodes* weevils to *Cimbex* sawflies and from *Limenitis* butterflies to *Smerinthus* sphinx moths (Cannings and Scudder 2005) but is thought to be primarily a forest-inhabiting species and thus may not attack Island Tiger Moth extensively. This species, other introduced tachinids and other parasitoids (e.g., ichneumonid and braconid Hymenoptera) may have some effect on Island Tiger Moth populations.

Problematic native species (Threat 8.2)

Natural forest succession of native trees, shrubs and herbaceous vegetation will eventually decrease the size and quality of Island Tiger Moth habitats. Potential larval host plants and adult nectar sources require open habitat with abundant light and moisture (see Pojar and McKinnon 1994 for associated habitat information on potential host plants) (see Habitat Requirements and Life Cycle and Reproduction). Natural forest and shrub succession occurs rapidly within open habitats where Island Tiger Moth has been captured. Natural succession from native plants such as Roadside Rock Moss [*Racomitrium canescens*]), Douglas-fir (*Pseudotsuga menziesii*) and Lodgepole Pine (*Pinus contorta*) occur in scattered patches throughout three recent Island Tiger Moth sites (sites 1, 3, 4). Goose Spit has some Douglas-fir and Lodgepole Pine natural succession at the westernmost tip (in the portions owned by 19 Wing Comox and Comox First Nation). Both Savary Island and Sandy Island have tree, shrub and moss ingrowth in the inner island open sand areas, as well as along the foreshore-beach interface.

Subpopulations of Island Tiger Moth are likely at risk from demographic collapse, which may be exacerbated by other threats over time by natural forest succession. Within Garry Oak and associated habitats, fire suppression (Threat 7.1) has led to further natural forest succession within these open habitats (GOERT 2011), and thus a decline in potential Island Tiger Moth habitats. Like other species confined to patchy habitats, populations of Island Tiger Moth are isolated and as natural forest succession continues at variable rates in surrounding habitats, those populations will become more isolated and fragmented (see Habitat loss, degradation and fragmentation). In some areas, natural succession may be delayed and/or forest harvesting may create open habitat for the expansion of Island Tiger Moth populations.

Natural system modifications (Threat 7.)

Fire and fire suppression (Threat 7.1)

The threat of fire and fire suppression activities are present throughout the range of Island Tiger Moth, particularly within natural tracts of land, areas adjacent to roadways and right-of-ways (e.g., where someone could potentially discard a lit cigarette), and in recreational areas where unattended campfires may smolder. Brush clearing, piling and periodic burning of vegetation and woody debris occur on private and public lands throughout the range of Island Tiger Moth. Although burning would only impact small areas of land, there is the possibility of overlap with unknown occurrences of the moth. The smoke generated from periodic brush burning, and the resultant char and burned debris are also detrimental to habitat quality. Mowing and cutting of vegetation within sites may impact Island Tiger Moth through decreasing available moisture retention within habitats, increasing dehydration stress to individuals and direct mortality.

Pollution (Threat 9.)

Agricultural and forestry effluents (Threat 9.3)

All of the Canadian range of Island Tiger Moth is within the potential range of introduction of European Gypsy Moth. Areas throughout Island Tiger Moth range do occur along prominent points of potential entry for Gypsy Moth and traps to detect introductions of this moth are scattered throughout this area (Burleigh pers. comm. 2012).

Should European Gypsy Moth be found in significant numbers there is the possibility of ground and aerial spray of Btk (*Bacillus thuringiensis kurstaki*). Btk is a component of commercial pesticide products that uses spores of a naturally occurring pathogenic bacterium to control defoliating caterpillars, although the bacterium also affects most non-target butterfly and moth larvae. Btk for Gypsy Moth is typically applied in early April to early May, coinciding with previous collections of Island Tiger Moth larvae (Table 1). According to October 2012 trap results, there is no planned spray of Btk within the range of Island Tiger Moth in 2013 (Burleigh pers. comm. 2013). It is unknown if these areas still contain populations of Island Tiger Moth, although there is certainly potential habitat within the respective spray zones.

The area of Btk application depends on the extent to which Gypsy Moths are trapped during surveys and this varies yearly. Gypsy Moth treatment areas since 1979 are shown in Figure 5 and Table 7, and the cumulative impacts of this spray program may have contributed to extirpation at some historical sites. Because trap results are compiled over at least two years, should Gypsy Moth be recorded there would likely be time to seek treatment options rather than simply broadcast aerial sprays. Treatment from backpack or truck from the ground may successfully eradicate the pest while having minimal impact on Island Tiger Moth. It is unlikely Island Tiger Moth would be eradicated from its entire range, although it could be significantly impacted.

Table 6. IUCN Threats calculator results for Island Tiger Moth (*Grammia complicata*) in Canada.

The threat classification below is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system and is consistent with methods used by COSEWIC, B.C. Conservation Data Centre and B.C. Conservation Framework (B.C. Ministry of Environment 2011a). For a detailed description of the threat classification system, see the Conservation Measures Partnership website (CMP 2010). For information on how the values are assigned, see Master et al. (2009) and table footnotes for details. Threats for Island Tiger Moth were assessed across the species' geographic range in Canada.

Island Tiger Moth (*Grammia complicata*)			
Date of Assessment: 2013-02-21			
Assessors: Jennifer Heron			
		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	1	1
B	High	1	0
C	Medium	4	5
D	Low	0	0
	Calculated Overall Threat Impact:	Very High	Very High

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	Moderate (Possibly in the short term, < 10 yrs)	Potential to impact 2 sites: Savary Island [housing development] and Goose Spit [commercial development]). Small impact to 3 sites from recreational development. Unknown impact to Thetis Island site or Nanoose Hill site.
1.1	Housing & urban areas	C	Medium	Restricted (11-30%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	Applicable to site 3 Savary Island: habitat owned by a private landowner and the Nature Trust.
1.2	Commercial & industrial areas	C	Medium	Restricted (11-30%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	Threat applicable to Site 1 Goose Spit - three land managers/owners: 1) HMCS Quadra 19 Wing Comox - threat is not presently applicable;however, land is a military training base, and the possibility of expanding the footprint of existing buildings is possible in the future; 2) Comox First Nation - unconfirmed plans for commercial development as a marina, restaurant, possibly casino 3) Comox Regional District - threat not applicable.
1.3	Tourism & recreation areas	C	Medium	Large (31-70%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Threat is applicable to 3 sites, although all sites consider ecosystem values when developing recreational infrastructure. Site 1 Goose Spit – portion managed by Comox Regional District who operates Goose Spit Park. The area is a popular picnic and bathing beach area (e.g., sandy beach). Recent small footprint construction of washroom facilities and parking spaces result in small areas being cleared. Staff are careful to minimize clearing at risk habitat; Site 3 Savary Island - The area is a popular walking and bathing beach, especially in summer months; Site 4 Sandy Island – park planning considers species and habitats at risk when developing areas (e.g., washroom and wooden camping pad placement).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture		Not a Threat (in the assessed timeframe)			Insignificant/Negligible (Past or no direct effect)	May have impacted 10 historical sites with vague site/collection information.
2.1	Annual & perennial non-timber crops		Not a Threat (in the assessed timeframe)			Insignificant/Negligible (Past or no direct effect)	Considered but not applicable. Clearing of land for agricultural areas is not as common as in the past. If land is cleared, it is usually for housing/commercial development, because the land is very valuable.
2.2	Wood & pulp plantations						N/A
2.3	Livestock farming & ranching		Not a Threat (in the assessed timeframe)			Insignificant/Negligible (Past or no direct effect)	Considered. Perhaps historically livestock grazing may have had an impact at some sites, but many of these areas have since been converted to urban use and/or have ongoing intensive agricultural use (e.g., crops). Not considered a present day threat.
2.4	Marine & freshwater aquaculture						N/A
3	Energy production & mining						
3.1	Oil & gas drilling						N/A
3.2	Mining & quarrying						N/A
3.3	Renewable energy						N/A
4	Transportation & service corridors	C	Medium	Large (31-70%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Potential impact to site 1: Goose Spit and 3: Savary Island. Not likely to impact Thetis Island. Will not impact Sandy Island.
4.1	Roads & railroads	C	Medium	Large (31-70%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Applicable to 2 sites: Site 1 Goose Spit, three landowners - Comox First Nations owns the tip of Goose Spit and at present there is a gate preventing vehicles from driving out to the land. There are potential plans to widen the road and possibly pave/gravel the road and allow full access to the site. Applicable to Site 3 Savary Island – possible development.
4.2	Utility & service lines	C	Medium	Large (31-70%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Applicable to Site 1 Goose Spit and Site 3 Savary Island (see above).
4.3	Shipping lanes						N/A
4.4	Flight paths						N/A
5	Biological resource use						Considered at Goose Spit site only. Negligible impacts.
5.1	Hunting & collecting terrestrial animals						N/A
5.2	Gathering terrestrial plants		Not a Threat (in the assessed timeframe)			Insignificant/Negligible (Past or no direct effect)	Considered. Goose Spit is of cultural significance to First Nations and there are culturally significant plants growing throughout the habitat. Impacts from gathering are negligible.
5.3	Logging & wood harvesting						N/A
5.4	Fishing & harvesting aquatic resources						N/A
6	Human intrusions & disturbance	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Potential impact to three sites: Site 1 Goose Spit; Site 3 Savary Island and Site 4 Sandy Island. Not likely to impact Thetis Island.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational activities	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Applicable to three sites: Site 1 Goose Spit – has three landowners. HMCS Quadra 19 Wing Comox holds a Sea Cadet Summer Training Camp each summer, and uses an obstacle course permanently situated within the natural sand dune habitat at Goose Spit. There are other SAR on the property, and the environmental management staff at 19 Wing Comox have developed site specifc plans that minimize trampling and protect both the species and habitat; Goose Spit Comox Regional District Park - popular day use beach and picnic area, with threats to ecosystem from trampling, digging (e.g., sand castles), clearing of vegetation for sun bathing, and cars parking along the narrow roadsides; 3) Comox First Nation - applicable recreational use. At site 3 Savary Island - popular area for walking, trampling of vegetation, sun bathing, and small clearing of vegetation for camping. At site 4 Sandy Island - Some areas within the park are used by 19 Wing Comox for sea cadet training during summer months. A site management plan has been created by 19 Wing Comox to minimize impacts to sand dune and other fragile ecosystem values. There are wooden camping pads on the island, although camping often occurs off these wooden pads. The island is visited often by boaters and recreational users. There is a large sandy beach and hiking trails traversing the island.
6.2	War, civil unrest & military exercises						N/A
6.3	Work & other activities						N/A
7	Natural system modifications		Not a Threat (in the assessed timeframe)	Pervasive (71-100%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs)	
7.1	Fire & fire suppression		Not a Threat (in the assessed timeframe)	Pervasive (71-100%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs)	Fire suppression is ongoing throughout the area, and has been in place for > 100 years. At all known sites fire suppression is considered a threat. Island Tiger Moth is considered extirpated (historical) from 3/8 sites, threat not applicable unless species presence confirmed.
7.2	Dams & water management/use						N/A
7.3	Other ecosystem modifications						N/A
8	Invasive & other problematic species & genes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Applicable at Site 4 Sandy Island - Scotch Broom and other invasive plants are throughout the site. Site 1 Goose Spit – 19 Wing Comox staff recently removed a large area of broom, with the objective of recovering the sand ecosystems, and simultaneously removing cover being used by introduced rabbits. Comox Regional District controls some Scotch Broom, although there is not much invasion within this part of the property. Site 3 Savary Island - minimal Scotch Broom but invasive grasses/forbs; Site 4 Sandy Island - minimal Scotch Broom but invasive grasses/forbs.
8.2	Problematic native species	D	Low	Large (31-70%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs)	Native vegetation growth is evident at 2 sites: Site 1 Goose Spit - growth of Douglas-fir and shrub vegetation is slow; Site 4 Sandy Island - middle of Sandy Island has Douglas-fir and other native trees and shrubs, and there is ingrowth into the open meadow areas.
8.3	Introduced genetic material						N/A
9	Pollution	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	Unknown	
9.1	Household sewage & urban waste water						N/A
9.2	Industrial & military effluents		Not a Threat (in the assessed timeframe)			Insignificant/Negligible (Past or no direct effect)	May be applicable at Goose Spit (area managed by HMCS Quadra, 19 Wing Comox); however, not currently applicable.
9.3	Agricultural & forestry effluents	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	Unknown	Gypsy Moth spray, monitoring throughout the area.
9.4	Garbage & solid waste						N/A
9.5	Air-borne pollutants						N/A
9.6	Excess energy						N/A
10	Geological events						
10.1	Volcanoes						N/A
10.2	Earthquakes/tsunamis						Three sites are within tsunami zone (Sites 1, 2, 3, 4). Sand spit at or only slightly above sea level (< 10m elevation).
10.3	Avalanches/landslides						N/A
11	Climate change & severe weather	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	Unknown	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	Unknown	Applicable to all sites. Site 1 Goose Spit has experienced loss and/or erosion in the last ten years (due to storms and waves washing habitat away), and armouring of the north side of the spit was recently completed such that portions of the spit are prevented from further erosion. Prior to Goose Spit armouring, work that had been completed at the sand deposition source (of shifting sand, where sand would originally come from and be deposited at the spit), at cliffs north in Comox, to prevent homes and property from eroding into the Georgia Straight. Whole deposition process at Goose Spit has been altered from both cliff (sand source) armouring, and spit (sand deposition/erosion) armouring. Site 4 Sandy Island and Site 3 Savary Island - Ongoing sand deposition and/or erosion of the ecosystem.
11.2	Droughts						N/A
11.3	Temperature extremes						N/A
11.4	Storms & flooding	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Three sites are within flood zone and subject to periodic winter storms. Goose Spit experienced extensive dune loss in the past ten years, due to winter storms. Likely applicable to Thetis Island site, although unknown.

Table 7. Gypsy Moth Treatment History in B.C. (B.C. Ministry of Forests, Lands and Natural Resource Operations 2012).

General Geographic Area of Gypsy Moth Treatment	Year of Detection	Year of Treatment	Aerial Spray	Ground Spray	Mass Trapping	Unknown	Host Removal
Kitsilano*, Vancouver (Mainland)	1978	1979		x		x	
Ft. Langley (Mainland)	1982	1984				x	
Courtenay (Vancouver Island)	1983	1984				x	
Courtenay (Vancouver Island)	1983	1985				x	
Canadian Forces Base Chilliwack (Mainland)	1983	1985		x			
Canadian Forces Base Chilliwack (Mainland)	1983	1986		x			
Canadian Forces Base Chilliwack (Mainland)	1983	1987	x				
Kelowna (Mainland)	1986	1983	x	x			
Canadian Forces Base Colwood, Vancouver Island	1986	1988	x				
North Parksville (Vancouver Island)	1987	1988		x			
Parksville (Vancouver Island)	1987	1990	x	x			
North Saanich (Vancouver Island)	1990	1991	x	x			
Belmont Park (Vancouver Island)	1990	1992	x				
South Parksville (Vancouver Island)	1991	1992		x			
Richmond (Mainland)	1991	1993	x				
Burnaby (Mainland)	1992	1993	x				

General Geographic Area of Gypsy Moth Treatment	Year of Detection	Year of Treatment	Aerial Spray	Ground Spray	Mass Trapping	Unknown	Host Removal
Salt Spring Island (Gulf Island)	1991	1993		x			
Victoria (Vancouver Island)	1992	1993	x				
Hope (Mainland)	1992	1993	x				
South Vancouver (Mainland)	1991	1994		x			
Victoria (Vancouver Island)	1992	1994	x				
Beban Park, Nanaimo (Vancouver Island)	1992	1994	x				
Whiskey Creek (Vancouver Island)	1992	1994	x				
Hope (Mainland)	1992	1994	x				
Chilliwack (Mainland)	1992	1995	x	x			
Hope (Mainland)	1992	1996	x				
New Westminster (Mainland)	1995	1997					x
Victoria (Vancouver Island)	1996	1998		x			
Colwood (Vancouver Island)	1996	1998		x			
Esquimalt (Vancouver Island)	1996	1998		x			
Victoria (Vancouver Island)	1996	1999	x				
Colwood, (Vancouver Island)	1996	1999	x				
Esquimalt (Vancouver Island)	1996	1999	x				
Duncan, Vancouver Island	1998	1999	x				
Nanaimo (Vancouver Island)	1998	1999	x				
Brentwood Bay (Vancouver Island)	1998	1999	x				
Tsawwassen (Mainland)	1998	1999	x				
Metchosin (Vancouver Island)	1998	1999	x				
Burnaby (Mainland)	1999	2000	x				
Sechelt (Mainland)	1999	2000			x		
Sechelt (Mainland)	2000	2001			x		
Sechelt (Mainland)	2001	2001			x		
Delta (Mainland)	1998	2001		x			
Delta (Mainland)	1999	2001		x			
Delta (Mainland)	2000	2001		x			
North Delta (Mainland)	2001	2002			x		
Saanich (Vancouver Island)	2001	2002			x		
North Delta (Mainland)	2002	2003			x		
Saanich (Vancouver Island)	2002	2003			x		
North Delta (Mainland)	2003	2004	x		x		
Saanich (Vancouver Island)	2003	2004	x		x		
Abbotsford (Mainland)	2003	2004			x		
Duncan (Vancouver Island)	2003	2004			x		
Gabriola Island (Gulf Island)	2003	2004			x		

General Geographic Area of Gypsy Moth Treatment	Year of Detection	Year of Treatment	Aerial Spray	Ground Spray	Mass Trapping	Unknown	Host Removal
Duncan (Vancouver Island)	2003	2005			x		
Duncan (Vancouver Island)	2004	2005			x		
Gabriola Island (Mainland)	2003	2005			x		
Gabriola Island (Mainland)	2004	2005			x		
Saanich (Vancouver Island)	2003	2005			x		
Saanich (Vancouver Island)	2004	2005			x		
Langley (Mainland)	2003	2005			x		
Langley (Mainland)	2004	2005			x		
Nanaimo (Vancouver Island)	2003	2006					
Nanaimo (Vancouver Island)	2004	2006					
Nanaimo (Vancouver Island)	2005	2006		x	x		
Saltspring Island (Gulf Island)	2003	2006					
Saltspring Island (Gulf Island)	2004	2006					
Saltspring Island (Gulf Island)	2005	2006		x	x		
Saanich (Vancouver Island)	2003	2006					
Saanich (Vancouver Island)	2004	2006					
Saanich (Vancouver Island)	2005	2006		x			
Courtenay (Vancouver Island)	2006	2007	x				
Saltspring Island (Gulf Island)	2006	2007	x	x	x		
Cedar Hill Golf Course (Vancouver Island)	2006	2007		x	x		
Belmont Park, Colwood (Vancouver Island)	2006	2007		x	x		
Saltspring Island (Southern Gulf Island)	2004	2008		x			
Saltair, near Ladysmith (Vancouver Island)	2007	2008		x			
Lake Cowichan (Vancouver Island)	2007	2008			x		
Harrison (Mainland)	2009	2009	x				
Harrison (Mainland)	2010	2010		x			
Richmond (Mainland)	2010	2010	x				

* 1979 treatments did not use Btk. All remaining aerial and ground spray treatments used Btk.

Aerial spray treatments involve aerial applications using aircraft over a pre-determined spray zone. Treatments are typically applied three times on three separate dates within the larval activity period for Gyspy Moth, April and May. Ground spray treatments involve hand held hydraulic sprayers that directly spray foliage within treatment zone. Mass trapping involves a grid of pheromone baited traps within a treatment zone. Host tree removal involves removal of vegetation thought to be the prime source of the initial introduction.

Climate change and severe weather (Threat 11.)

Habitat shifting & alteration (Threat 11.1)

Increased summer droughts may affect habitat within Island Tiger Moth sites and will decrease the available site moisture that allows for suitable host plant growth. By 2050, mean annual temperatures are expected to rise approximately 2 - 3°C (Hebda 1997). Within the Pacific Maritime Ecozone (where Garry Oak ecosystems, coastal sparsely vegetated sand dune ecosystems, and Island Tiger Moth occurs in Canada) temperatures from 1960 – 2006 increased by 1.71 °C (Coristine and Kerr 2011). Conversely, there is an anticipated increase in winter precipitation that is projected for coastal areas such as east Vancouver Island. A recent analysis of global observations from 1925 to 1999 showed that precipitation increased by 6.2 mm per decade in the latitude band of 50 to 70 degrees north, which includes almost all of British Columbia (Zhang *et al.* 2007). More specifically, in southeastern Vancouver Island the projected change in precipitation by the middle of the 21st century (2041 – 2071), relative to historical records (1961–1990) models a 10 – 25% increase for average winter conditions (December, January, February) and a 0 – 10% increase for average summer conditions (June, July, August) (Pacific Climate Impacts Consortium April 2007 (analysis); Consortium Ouranos and Canadian Centre for Climate Modeling and Analysis (data and modeling) as read in Environmental Trends in British Columbia 2007). Threat 11.2 (Droughts) applies to all recent Island Tiger Moth sites.

Storms and flooding (Threat 11.4)

Coastal erosion and stochastic events are threats to sand dune habitat (as applicable to endangered Sand-verbena Moth habitat within 100 m of the shoreline (often within 25 m) (B.C. Invertebrates Recovery Team 2008). These events could also impact Island Tiger Moth habitat along the more stabilized dune areas. Threat 11.4 (Storms and Flooding) applies to all recent Island Tiger Moth sites and likely to the Thetis Island site.

Historical threats to Island Tiger Moth

Threats or reasons for the extirpation of Island Tiger Moth from historical sites are speculative (see **Habitat Trends**). Not all historical sites may have been resurveyed due to the lack of detail on the specific collection site (see Table 1 for available locality information). Extensive land development and habitat conversion, leading to population isolation and demographic collapse are likely the main threats to historical populations. Many of these historical sites are also now dominated by invasive plant species.

Limiting Factors

The main limiting factors for Island Tiger Moth are speculative but are likely a combination of microhabitat: sunny, sparsely vegetated sites with abundant cover for hidden pupation sites. Host plants are likely not a limiting factor (Schmidt pers. comm. 2012). Female moths are not highly mobile and are unlikely to disperse far due to their heavy bodies. The population structure and spatially isolated habitats likely limit dispersal capabilities and population intermixing.

Natural predatory and parasitic enemies are known to attack tiger moths during all life stages (Wagner 2009) (see **Interspecific Interactions**) although there is no species-specific information on Island Tiger Moth. Although minor, the eggs and larvae of Island Tiger Moth may be subject to direct mortality or damage by browsing animals. Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) and Roosevelt Elk (*Cervus canadensis roosevelti*) have been observed browsing on vegetation throughout the open habitats where Island Tiger Moth occurs, and may trample larvae or host plants.

Number of Locations

The number of locations for Island Tiger Moth is 5 – 8 locations, based on threat of development (from different land ownership); three on Goose Spit (three different land managers with differing development outcomes), two on Savary Island (two different landowners), one on Sandy Island (provincial park), 1 – 2 at Nanoose Hill (federal land and regional government park) and one is assumed for Thetis Island.

Habitat loss and degradation from a combination of invasive species including Scotch Broom (all locations), natural forest succession due to fire suppression (all locations), and recreational use in some locations (particularly Sandy Island, Goose Spit, Savary Island and the regional government portion of Nanoose Hill) are mutually exclusive threats that impact most sites and contribute to an overall decline in habitat quality. Btk would impact actively conserved sites, although this would not likely occur simultaneously at all locations. See Threats.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Island Tiger Moth is not legally defined as wildlife under the B.C. *Wildlife Act*. Invertebrates assessed by COSEWIC and listed under the federal *Species at Risk Act* as Threatened, Endangered or Extirpated will be protected through the B.C. *Wildlife Act* and *Wildlife Amendment Act* once the regulations listing these species are completed.

Both the B.C. *Park Act* and *Ecological Reserves Act* afford legal protection to invertebrate species at risk in provincial parks and protected areas. When species at risk and the habitats they require are known to occur within a protected area, provisions for management are incorporated into the park master plan.

Island Tiger Moth is not currently protected by federal laws.

Non-Legal Status and Ranks

Island Tiger Moth has not been assigned a conservation status in B.C. (B.C. Conservation Data Centre 2012) although preliminary conservation status assessment places the moth status at S1 (Critically Imperiled, Red-listed). The national rank (Canada) is N1N2 (Critically Imperiled to Imperiled); global rank is G1G2 (Critically Imperiled to Imperiled; NatureServe 2012). In WA the species is not ranked (NatureServe 2012).

Island Tiger Moth has not been assessed under the B.C. Conservation Framework (2012) although it would likely be categorized as a priority one species (highest priority) under goal three (maintain the diversity of native species and ecosystems). The Canadian and B.C .General Status rank is "May Be at Risk" (Wild Species 2010).

Habitat Protection and Ownership

Most land within the range of Island Tiger Moth is privately owned. Ownership is by private citizens (e.g., lowland farms or rural properties) or local governments (e.g., municipal parks including sparsely vegetated beach areas). There is no legislative protection specifically for Island Tiger Moth habitat on privately owned lands in B.C.

Provincial parks and protected areas

Island Tiger Moth has been recorded from Goldstream Provincial Park (site 7) (1903, historical), Spectacle Lake Provincial Park (site 8) (1964, historical) and Sandy Island Provincial Park (site 4, recent) (2000) (B.C. Conservation Data Centre 2012). The exact collection site at each of the historical sites is unknown. Lands managers at 4) Sandy Island Provincial Park are aware of the species and work to incorporate habitat protection into park planning (Chapman pers. comm. 2010; Pratt pers. comm. 2011). Park plans at 7) Goldstream Provincial Park and 8) Spectacle Lake Provincial Park currently do not consider Island Tiger Moth.

At site 4 Sandy Island Provincial Park, some areas within the park are used by HMCS Quadra 19 Wing Comox for sea cadet training during summer months. A site management plan has been created by HMCS Quadra 19 Wing Comox to minimize impacts to sand dune and other fragile ecosystem values.

Federal properties

Island Tiger Moth has been recorded from three sites under federal management: the portion of Goose Spit (site 1) managed by HMCS Quadra 19 Wing Comox (2003); the portion of Nanoose Hill (site 9; in 2012) and one historical site at Observatory Hill (Herzberg Institute of Astrophysics) (site 6) in Victoria (1957, 1958, 1961).

HMCS Quadra 19 Wing Comox holds a sea cadet summer training camp at Goose Spit each summer, and uses an obstacle course permanently situated within the natural sand dune habitat at Goose Spit. There are other species at risk on the property, and the environmental management staff at HMCS 19 Wing Comox have developed site specific plans that minimize trampling and protect both the species at risk and habitat.

Regional and municipal government-owned lands

One historical site, Mount Douglas Park (1956) is a local government (Saanich) park. The species is assumed present in Goose Spit Comox Regional District Park, which is immediately adjacent to the recent site HMCS Quadra 19 Wing Comox Goose Spit (site 1). Land managers are aware of the species and its habitat needs (Comox Regional District parks, [Albert pers. comm. 2011]; Saanich parks [Pollard pers. comm. 2011]; [Copley [D] pers. comm. 2011]).

Private conservation land

Habitat on Savary Island (site 3) spans two landowners, the Nature Trust and a private citizen. The Nature Conservancy manages two parcels of habitat where Island Tiger Moth could potentially occur: James Island (near Sidney) and Cowichan Garry Oak Preserve (near Duncan). Ultraviolet light trapping at both sites has not confirmed presence of Island Tiger Moth.

Private property and private forestland

Much potential Island Tiger Moth habitat on southeastern Vancouver Island and Gulf Islands is privately owned by individual landowners (e.g. farms or rural properties) or within local government ownership (e.g. municipal or regional parks).

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COLLECTIONS EXAMINED

- Royal British Columbia Museum, Victoria, B.C. (Claudia Copley pers. comm. 2010)
- University of British Columbia, Beaty Biodiversity Museum, Spencer Entomological Collection (Karen Needham pers. comm. 2010).
- Washington State University James Entomological Collection, Department of Entomology, Pullman, Washington (not examined). No collection records. (R. Zack pers. comm. 2010).
- Canadian National Collection of Insects, Arachnids, and Nematodes, Biodiversity Program, Agriculture and Agri-Food Canada, K.W. Neatby Bldg., (not examined). Collection records electronically sent (B.C. Schmidt pers. comm. 2010).